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Using Remote Sensing for the Investigation of *Vibrio parahaemolyticus* in Gulf Coast Oysters (*Crassostrea virginica*) and Overlying Waters for Risk Assessment

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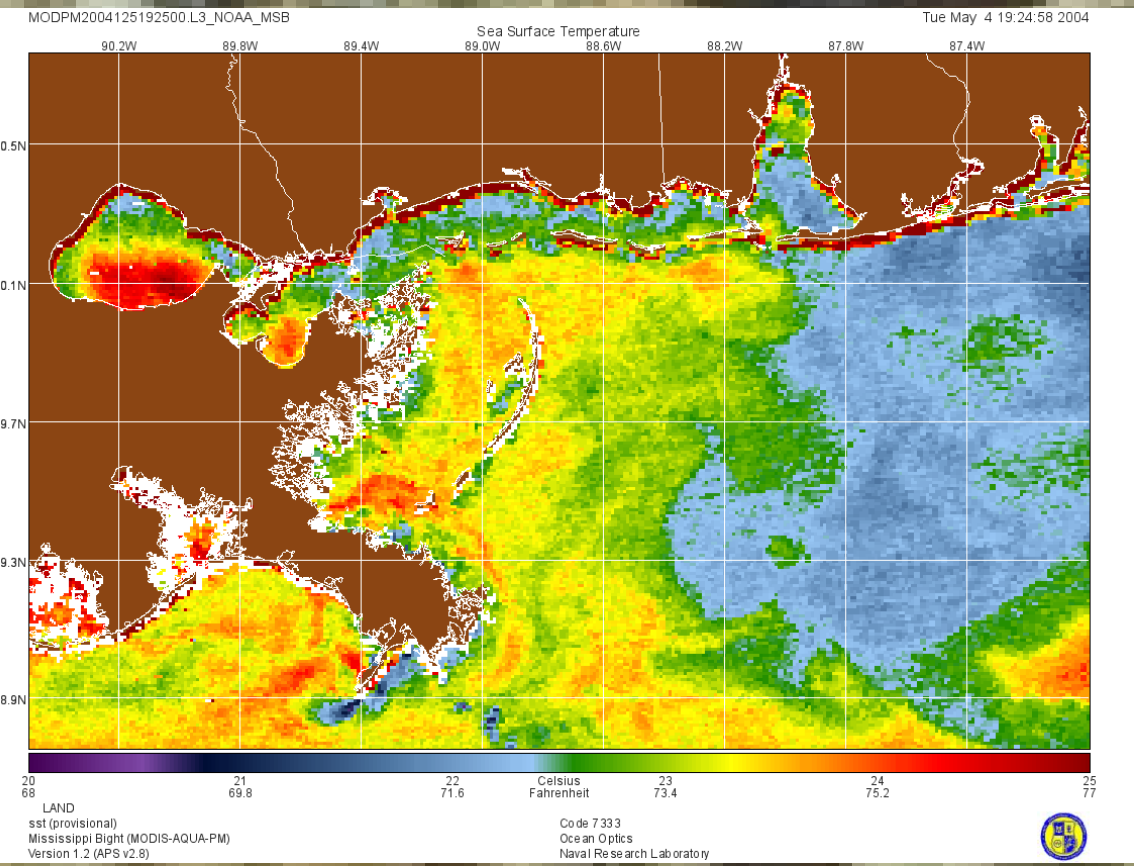
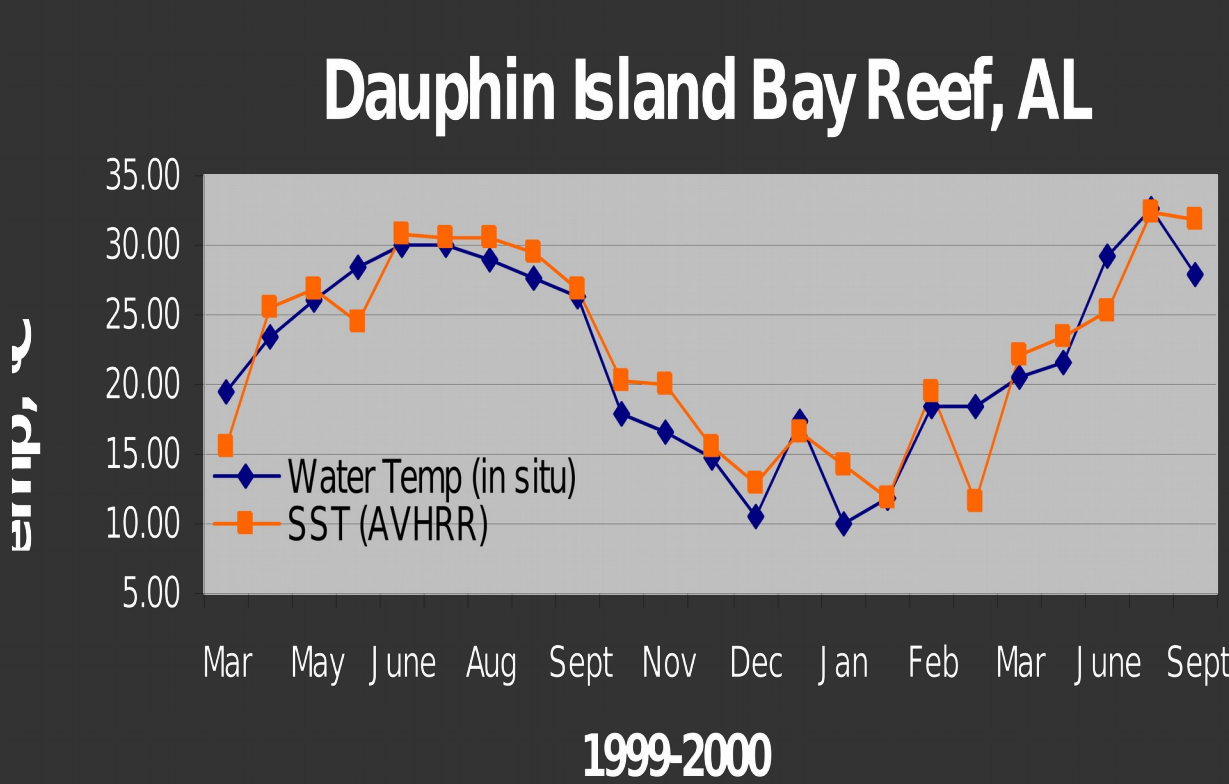
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ABSTRACT

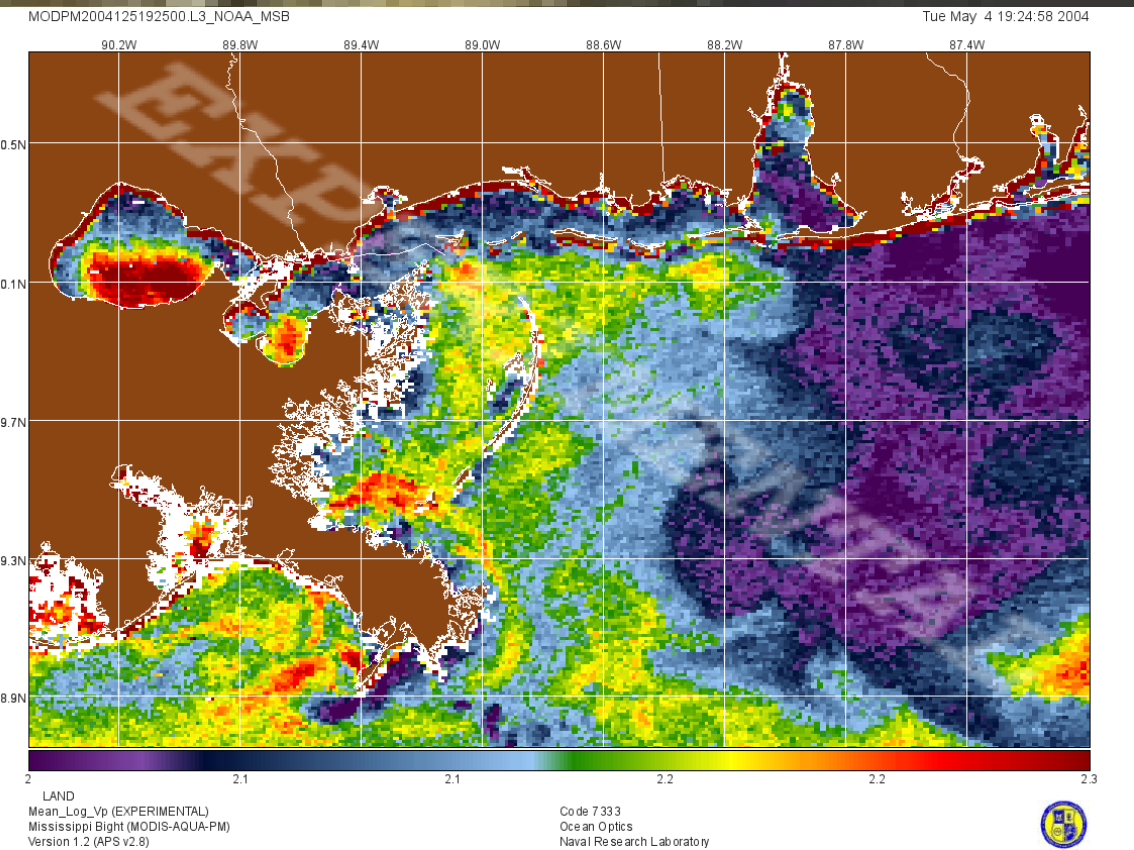
Vibrio parahaemolyticus (Vp), a commonly occurring bacterium indigenous to the marine and estuarine environment, is a frequent cause of food borne gastroenteritis affecting approximately 3000 people annually in the US, mostly due to consumption of raw or undercooked oysters. Water temperature has been shown to account for 50% of variability in Vp density; however, the factor(s) responsible for the other 50% are still unknown. Considering the highly dynamic nature of the coastal and estuarine areas where oysters are produced and harvested, *in situ* environmental sampling is not always feasible as it is resource intensive and sampling is limited both spatially and temporally. Therefore a remote sensing approach can be taken to supplement environmental sampling and thus be integrated into risk assessment models being developed by the FDA for predictions of risk associated with consumption of raw or undercooked shellfish. This study investigates possible environmental factors (i.e. sea surface temperature, chlorophyll, and turbidity) recorded from both *in situ* measurements and via remotely sensed satellite imagery, which may account for increased Vp density determined by DNA probe colony hybridization methods and real-time polymerase chain reaction (qPCR) assays. Statistical analysis shows significant correlations between Vp density and the environmental factors, suggesting these factors (other than temperature) may further explain Vp density variability and can be used for revision of the current FDA risk assessment model based solely on water temperature. Furthermore, *in situ* measurements significantly correlate with the respective remotely sensed data, supporting the notion that remotely sensed SST data are reliable and can be used in place of *in situ* sampling, as well as, imported into the FDA risk assessment model for real-time prediction of risk. A public access Vp monitoring website could be developed and used as an aid in making informed and timely decisions for intervention when the predicted risk may be high. This surveillance could reduce potential illness and thus increase consumer/retailer confidence in shellfish.

OBJECTIVES

- ❖ Determine whether ground referenced *in situ* environmental data correlates with remotely sensed data
- ❖ Develop a revised prediction model to relate *V. parahaemolyticus* incidence to opportune environmental conditions
- ❖ Implement remotely sensed data into a revised *V. parahaemolyticus* prediction model for virtual real-time monitoring of *V. parahaemolyticus* risk associated with eating raw oysters



MODIS SST image of SST along the LA, MS, and AL coasts May 4, 2004



Mean log Vp/g prediction image based on remotely sensed MODIS SST values May 4, 2004



Landsat image of Mississippi and Alabama coastline depicting Phase I (stars) and Phase II (diamonds) sampling stations

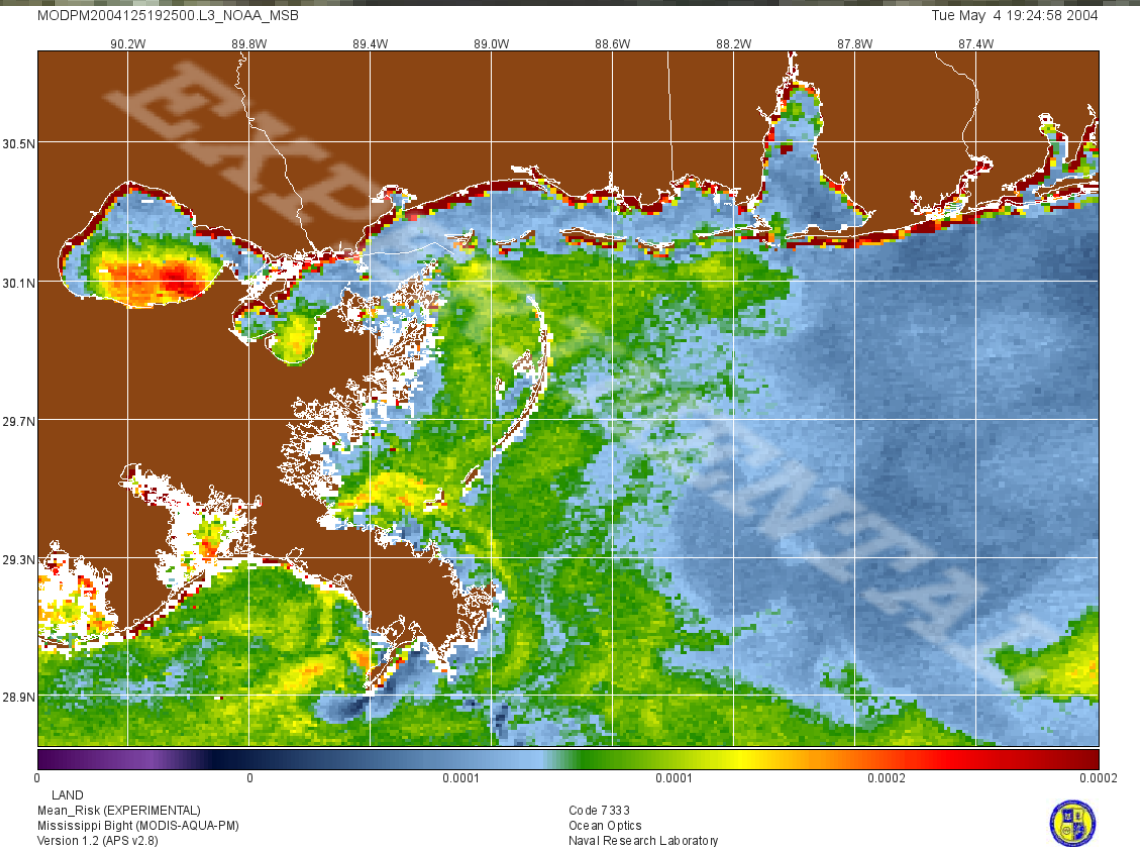
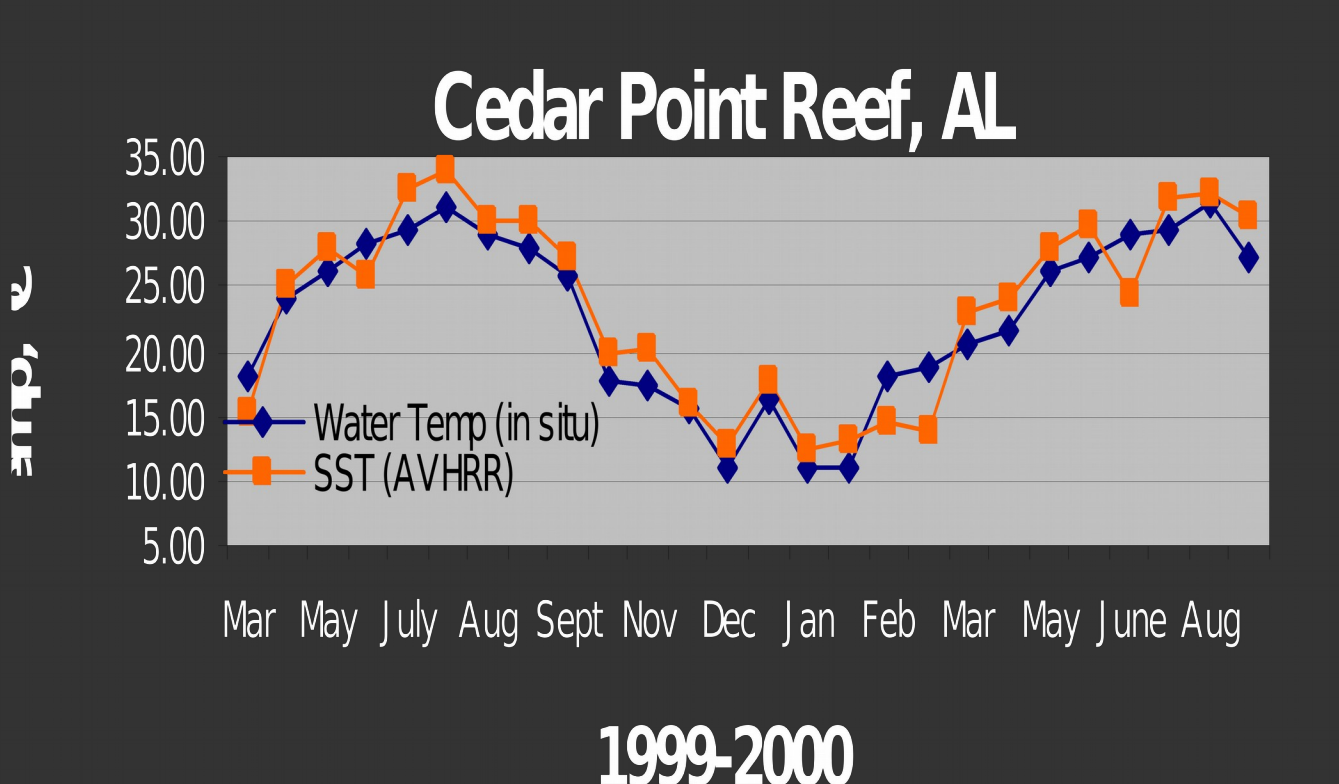
METHODS

Phase I

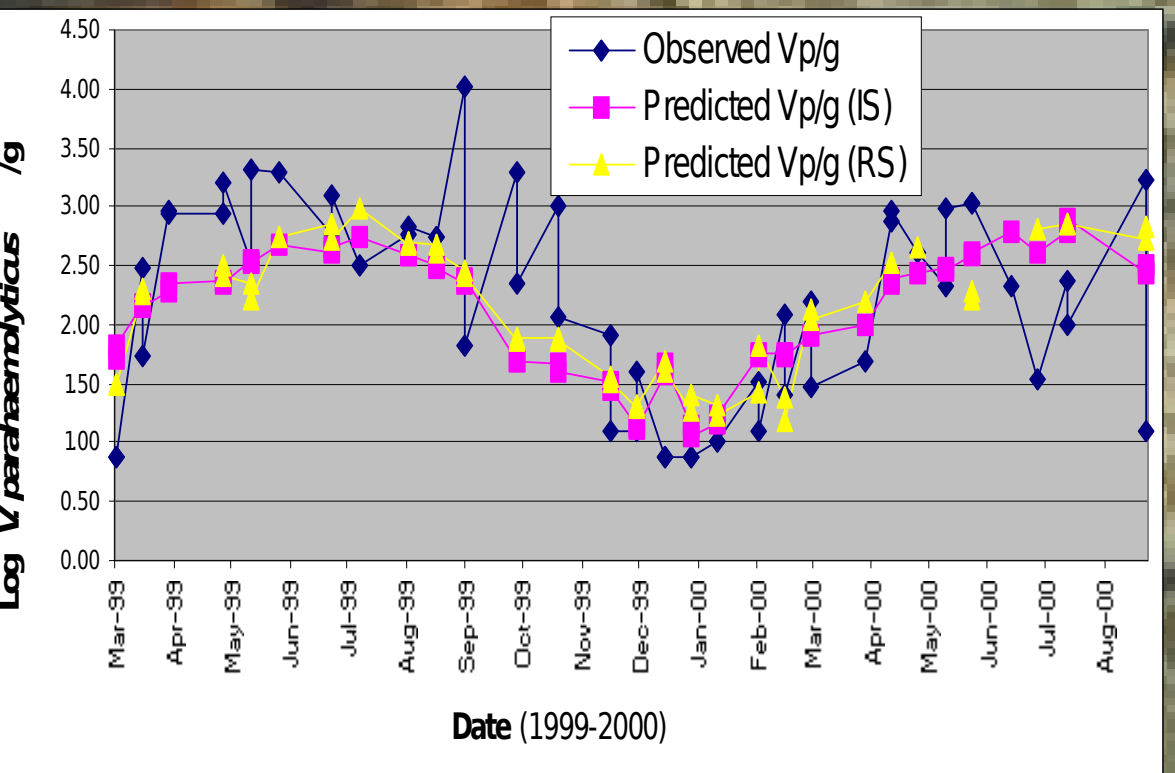
- ❖ Obtained historical *in situ* data for 2 stations near Mobile Bay, AL- March 1999 - September (FDA): *Vibrio parahaemolyticus* (Vp) density
Bottom water temperature
Salinity
- ❖ Obtained corresponding archived remote sensing (RS) data products for comparison with respective *in situ* data and Vp density (NRL): SST (AVHRR)
Turbidity (AVHRR)
Chlorophyll (SeaWiFS)
- ❖ Implement both *in situ* and RS surface temperature data into prediction model for comparison of Vp density predictions

Phase II

- ❖ Oyster and water samples were collected once and three times per week (on average), respectively from May - Sept. 2004 at 2 stations: Dauphin Island, AL
Ocean Springs, MS
- ❖ *In Situ* environmental/water quality data collected: Top/bottom water temperature
Salinity
Turbidity
Chlorophyll
- ❖ Enumeration methods used for detection of total (tlh) and pathogenic (tdh and/or trh) *Vibrio parahaemolyticus*: Direct plating/Colony Hybridization
qPCR on triplicate multi-volume enrichment samples (quantified by MPN)
- ❖ Obtained corresponding RS data products (NRL): SST (MODIS)
Turbidity (MODIS)
Chlorophyll (MODIS)
- ❑ Pixel values were extracted from RS products using ENVI image analysis/processing software
- ❑ Data analyses carried out using SPSS and/or SAS statistical software
Environmental data vs. Vp density
In situ data vs. RS data (SST, chlorophyll, turbidity)



Mean risk of illness prediction image based on remotely sensed MODIS SST values May 4, 2004



V. parahaemolyticus (Vp) predictions based on remotely sensed and in situ temperature data vs. observed Vp density for both Phase I stations

RESULTS/DISCUSSION

PHASE I

- ❖ *In situ* water temperature data highly significantly ($P < 0.001$) correlated with remotely sensed (RS) SST data thus can be used in place of *in situ* data ($R^2 = 0.86$)
- ❖ Predictions based on *in situ* vs. RS temperature values showed $<0.5\%$ difference on average when imported into model: $\log Vp/g = a + b * SST$, where a and b are regression parameter estimates ($R^{22} = 0.41$)
- ❖ A highly significant ($P < 0.001$) correlation was found between observed Vp and e predicted Vp based on surface temp values
- ❖ Abundance of total *V. parahaemolyticus* (tlh) in oysters was seasonal and affected greatly by temperature and moderately by salinity
- ❖ Remotely sensed chlorophyll data (although limited) appeared to play a predictive role in Vp, suggesting Vp densities are associated with phytoplankton

PHASE II

- ❖ As in Phase I, RS data (SST, chlorophyll, and turbidity) showed a highly significant ($P < 0.001$) correlation with the respective *in situ* data
- ❖ *V. parahaemolyticus* abundance (total and pathogenic) in oysters and water seemed to be affected differently by variables measured at two different stations
- ❖ Regression analysis revealed a significant ($P < 0.05$) association between Vp density at the MS site and both turbidity (tlh, tdh, and trh) and chlorophyll (tdh) when looked at without the effect of temperature and salinity.
- ❖ There was not a significant association with turbidity nor chlorophyll with Vp (total or pathogenic) at the AL site; this could be due to the possibility that those factors may not have varied enough at that site

- ❖ The differences in frequency of detection in water and oyster samples of total (tlh) and pathogenic (tdh and/or trh) Vp showed dramatic differences
 - All but 1 sample were positive for total Vp
 - Pathogenic (both tdh and trh) were more prevalent at the MS station
 - MS water had three times more tdh + and double the trh + Vp

Acknowledgements

NOAA, Oceans and Human Health Initiative, USM, Gulf Coast Research Laboratory, Ocean Springs, MS; FDA, Gulf Coast Seafood Laboratory, Dauphin Island, AL; Naval Research Laboratory, Stennis Space Center, MS; NOAA, National Marine Fisheries Service, Pascagoula, MS; MS Department of Marine Resources, Biloxi, MS